FEEDING ECOLOGY OF INDIAN PORCUPINE (*HYSTRIX INDICA* KERR) IN COCONUT (*COCOS NUCIFERA* L.) PLANTATIONS OF THE WESTERN GHATS OF KARNATAKA[1]

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Feeding ecology of the Indian Porcupine *Hystrix indica* Kerr in and around coconut plantations in the Western Ghats of Karnataka, southern India, was studied during 2001-2002. A survey of four districts in the study area showed that this species fed on 16 species of plants and was a major pest to the coconut plantations. It debarked the palm, fed on fallen nuts, injured seedlings to the point of no further growth, and bored into the bole eventually causing mortality. Mortality of the palms depended on age – the younger the palm, the greater the damage (r=0.9206, P=0.05).
The Porcupines feed on coconut bark, principally, from September to January. Burrows were categorized as small and big, and the number of Porcupines corresponded to the size of the burrows (r=0.8972, P=0.05). Encroachment of forest lands by man has resulted in alternative foods of the Indian Porcupine becoming locally scarce in the wild. Hence, conserving its natural habitat is critical.

Key words: Indian Porcupine, damage, coconut plantations, Western Ghats, southern India

INTRODUCTION

The Indian Porcupine *Hystrix indica* Kerr (Family Hystricidae), a fossorial and nocturnal animal, is distributed throughout India from sea level to 2,800 m above msl (Agrawal and Chakraborthy 1992). The Indian Porcupine *Hystrix indica* Kerr, the Himalayan Crestless Porcupine *Hystrix brachyura* Linn., and the Brush-tailed Porcupine *Atherurus macrourus* Linn. are the three species found in India (National Plant Protection Training Institute 1998). Porcupines inhabit a wide variety of habitats from semi-arid scrublands to forested areas (Prater 1980). The estimation of population density of porcupines in the Middle East, under various habitat and environmental conditions, has been attempted (Alkon 1983; Gutterman 1987, 1988). Bhargava *et al.* (2001) recorded observations on the distribution in western Thar Desert, Rajasthan, while Sharma (2001) estimated relative density in semi-arid areas of Rajasthan through pellet counts. Observations on bark feeding behaviour have been recorded by Choudhary and Ahmad (1975). Sharma (1989) and Sharma and Prasad (1992) documented information on tree debarking and habitat use by porcupine in Sariska National Park, Rajasthan. Field data on foraging ecology in cultivated ecosystems of the Western Ghats region in Karnataka has also been recorded. (Srihari and Chakravarthy 2001). Chakravarthy and Girish (2002a) evaluated cultural and mechanical methods to protect coconut from porcupine damage in coastal Karnataka. Chakravarthy and Girish (2002b) also screened three varieties of coconut in coastal Karnataka and found equal feeding damage to all the varieties. In the Western Ghats and coastal Karnataka, Coconut (*Cocos nucifera* L.) plantations adjacent to or near evergreen tropical forests were severely damaged by porcupines. This study reports basic information on the feeding behaviour and damage caused to coconut plantations.

MATERIAL AND METHODS

Identification of Vertebrate pests

Animals foraging in coconut plantations were identified by direct sighting using a pair of 8 x 30 binoculars and headlights. The nature of damage and signs in the field, such as presence of quills, pugmarks were used as clues for identifying animals.

Study Area and Field Observations

Surveys were conducted using a four-wheel-drive vehicle during 2001 and 2002, in the districts of Shimoga (13° 51' 2.6" N, 75° 42' 25.9" E), Chikmagalur (13° 18' 44.3" N, 75° 46' 15.2" E), Hassan (5° 11' 15" N, 93° 35' 50" E), Kodagu (12° 24' 59" N, 75° 44' 8" E) and Dakshina Kannada (12° 51' 55" N, 75° 50' 29" E) in the Western Ghats of Karnataka, to document vertebrates feeding on coconut palms, alternate food plants, debarking pattern, temporal distribution of damage, feeding and foraging habits, and density and number of burrows per unit area. Alternate food plants were identified by a plant taxonomist. Damage by the Porcupine was correlated with its density, which was estimated from the number of burrows/ unit area. Twelve (four at each location) porcupine burrows were excavated at Kidu, Bhadra and Sakleshpur. The number

of Porcupines in each burrow was counted, and the area and other details of the burrow were recorded at different times of the year. Debarking by porcupine was identified by gnawing marks on the trunks of trees and presence of quills. Debarking signs were catagorised as new, old and cumulative (Sharma and Prasad 1992). To establish whether debarking by porcupines cause mortality in cococnut palms, continuous observations were recorded on the progress of feeding damage like burrowing, debarking, removing fibrous tissue, feeding on pith, damaging bole portion and finally the death of the palm. The seasonal use of bark, the palm species most used and the age of the palm when bark stripping occurred commonly were documented. The Kruskal-Wallace One-way Analysis of Variance (Siegel and Castallan 1988) was used to test the seasonal difference in bark damage.

Porcupine damage on coconut palms was recorded during the early morning hours (0600-0800 hrs), every month. Total bark damage would be a function of maximum height above ground level to which the porcupines can debark (0.6 m) x average diameter of the trunk. Twelve palms in a five year old Benalium coconut garden plot of one hectare, adjacent to a forest were chosen to monitor the debarking process. Area (sq. cm) of bark removed daily by porcupines was also measured.

Damage was catagorised as old, if it was more than a week old (damaged portion turning brown) and as new, if it was less than a week old (light yellow/ white coloured bark). The field data was subjected to ANOVA and least significant difference tests, damage and time being the main effects, with an interaction term of the main effects in the ANOVA model. Effect of palm age, distance of coconut plantation from forest patch and coconut variety on porcupine damage was evaluated in separate coconut plantations from November 2001 to September 2002. Debarking pattern was recorded daily by marking the healthy palms fed upon by porcupine. For testing the hypothesis that palms of different age groups have different degrees of damage by porcupine, Friedman's One-way Analysis of Variance followed by LSD was performed. During April and May, at Subramanya, porcupines were found feeding on cashew kernels adjacent to the coconut plantations. Percent damage was computed by counting the total number of kernels accessible to the animal divided by the number of kernels eaten during peak fruiting period.

RESULTS

Field Observations

Six species of vertebrates, including porcupine, were found feeding on coconut palms (Table 1). The method of debarking of coconut by porcupines differed from that of other animals. Porcupines debarked the palm using their incisors, i.e. they chipped-out bark pieces, exposing the pith. The Cervids debarked the palm by rubbing their antlers on it, causing stripping, but the pith is not exposed. In the areas surveyed, the Indian Wild Boar (*Sus scrofa*) (30-40% nut damage) and Porcupine (15-20% nut damage) were considered major pests.

Surveys in the Sakleshpur, Arsikere and Hassan talukas of Hassan district, Subramanya of Dakshina Kannada district, Mudigere, Bhadra project area and Tarikere of Chikmagalur district indicated the presence of Porcupine in all talukas of the study area. Feeding signs were found on 13 species of

Table 1: Vertebrates feeding on Coconut Palms in the Western Ghats of Karnataka

Species	% damage		Nature of damage	Identification	Economic impact
	seedling	fallen nuts			
Bonnet Macaque *Macaca radiata*	7	15	Big hole in the centre of the nut, skin peeled off	Direct observation	Major
Five striped Squirrel *Funambulus palmarum*	0	1-2	Small hole in the centre of the nut	Direct observation	Minor
Bandicoot Rat *Bandicota indica*	16	3-5	Small hole near the perianth / proximal end of the nut	Tracks	Minor
Indian Wild Boar *Sus scrofa*	3	30-40	Dehusk the nuts into bigger pieces and eat the endocarp	Tracks	Major
Indian Porcupine *Hystrix indica*	24	15-20	Debark the trunk, dehusk into thin fibres / pieces	Presence of quills and tracks	Major
Indian Bison *Bos gaurus*	0	1-2	Damage the seedlings	Tracks	Minor

Major: >10%; Minor: <10%; seedlings: n = 200; fallen nuts: n = 80

cultivated and wild plants, besides coconut (Table 2). The Porcupines foraged on cultivated crops like potato, groundnut and sweet potato and also species of *Phoenix*. They inhabited hillsides, boulders, and burrows.

In parts of the hills and coastal Karnataka, Porcupines differentially fed on 16 species of plants (Table 3); the sample size in this case was small and represented a subset of the available species. Porcupines appeared to feed preferentially on certain plant species while avoiding others. Feeding signs were also observed frequently on *Ipomea batatas*, *Bambusa* spp., *Dioscorea* spp., Rubber *Hevea braziliensis*, *Agave americana* and *Caryota urens*. The extent of damage to coconut depends on many factors – the most important being the age of the palm and the season. Seedlings and young coconut palms (less than 10 years) were more vulnerable to damage by porcupine feeding ($t=4.261$, $P=0.05$).

Debarking

To assess the impact of porcupine feeding on cultivated palm, the combined effect of burrowing, tissue feeding, bark stripping and browsing on ground vegetation was collectively considered. Porcupines debarked coconut palms of different ages, i.e. young (<5 years) to old palms (>30 years). The degree of damage caused differed with the age of the palm (Friedman's one-way ANOVA, $P=0.05$); young palms (15-23 year) suffered significant damage compared to older palms (27-30 year) (LSD, $P=0.05$). Most debarking occurred at the height of 0-75 cm. Debarking started from the bottom and progressed upward and sideways. No seasonal difference was found in the number of palms damaged by Porcupines (Kruskal-Wallace One-way Analysis of Variance $P>0.05$).

Porcupines debarked about (n=12) 44 sq. cm of bark from November to December 2001; 188 sq. cm bark/palm during December 2001 to January 2002; 250 sq. cm bark/palm during January 2002 to March 2002. However, the exact number of porcupines debarking coconut palms could not be established.

Cultivated coconut palms adjacent to the forest patch were more heavily damaged than those planted further away.

Table 2: Details of foraging by the Indian Porcupine on the crops and plants in the surveyed localities

Date	District	No. of visits	Geographic positions	Crops & plants with feeding signs
Nov. 24, 2001 to Nov. 8, 2002	Dakshina Kannada (Subramanya)	12	12° 51' 55" N, 75° 50' 29" E 281 m above msl	Cane *Calamus tenuis* Redt. Coconut *Cocos nucifera* L. Sweet Potato *Ipomea batatas* Lamk. Bamboo *Bambusa arundinacea* (Retz.) Tapioca *Manihot esculenta* Crantz. Alocasia *Alocasia indica* Schott. Cashewnut *Anacardium occidentale* L.
Jun. 1, 2002 to Sep. 17, 2002	Shimoga (B.R. Project)	4	13° 51' 2.6" N, 75° 42' 25.9" E 925 m above msl	Sweet Potato *Ipomea batatas* Lamk. Bamboo *Bambusa arundinacea* (Retz.) Tapioca *Manihot esculenta* Crantz Cane *Calamus tenuis* Redt. Coconut *Cocos nucifera* L.
Mar. 18, 2002 to Oct. 31, 2002	Chikmagalur (Mudigere)	3	13° 18' 44.3 " N, 75° 46' 15.2" E 982 m above msl	Cactus *Agave americana* L. Wild Turmeric *Curcuma aromatica* Salisb. Colocasia *Colocasia* indica L. Acacia *Acacia catechu* Willd.
Jan. 31, 2002 to Nov. 8, 2002	Hassan (Sakleshpur)	2 6	5° 11' 15" N, 93° 35' 50" E 100 m above msl	Banana *Musa paradisiacal* L. Cactus *Agave americana* L. Cane *Calamus tenuis* Redt. Wild Turmeric *Curcuma aromatica* Salisb. Colocasia *Colocasia* indica L. Gauri Gedde *Gloriosa superba* L. Byne Palm *Caryota urens* L.
Dec. 30, 2001 to May 24, 2002	Kodagu (Madikeri)	5	12° 24' 59" N, 75° 44' 8" E 1033 m above msl	Cactus *Agave americana* L. Wild Turmeric *Curcuma aromatica* Salisb. Colocasia *Colocasia* indica L. Gauri Gedde *Gloriosa superba* L.

Plot I was 0.3 km from forest, while plots II, III and IV were 0.8 km away. Plot I recorded 40% palm mortality, while plots II, III and IV recorded 10-22%. However, the effect of the distance from the forest was confounded with age, since palms differed in age between the plots. Porcupines caused higher mortality to younger palms. The data of the three plots equidistant from forest when analysed for palm mortality, showed a consistent relationship between age and mortality (r=0.9206, P=0.05). In general, it was observed during the surveys that palms less than ten year old were more vulnerable to damage.

One of the alternative food items in the study area was Cashew (*Anacardium occidentale*). Porcupines chewed the kernels, sucked the juice and left behind the kernels. Kernel damage due to porcupine feeding ranged from 6-12% (mean 7.25±1.72), while that due to other animals ranged from 11-17% (mean 14.25±2.18). During May 2002 porcupines did not use cashew kernels, but damage by other animals was 13%. Maximum damage to the cashew kernels by porcupine occurred during April when availability of kernels was high because of peak fruiting period. Damage was reduced drastically in May, when the fruiting season came to an end, as sufficient kernels were not available. There were no statistically significant differences in the damage caused by porcupines and other animals (T-test, P>0.05)

There were two types of porcupine burrows; the large burrows held 8-10 animals and small burrows held 2-3 animals. Seventeen (6 large, 11 small) porcupine burrows were located in 120 ha at Kidu, Subramanya, of which eleven were active, and six deserted. Porcupines preferred scrub jungle for making burrows. Detailed observations in and around 150 ha of Subramanya showed that they tunnelled under shrub thickets and dense ground vegetation. Observations in a number of localities in the Western Ghats of Karnataka showed that usually 2-3 animals were found in small burrows (n=30) compared to 8-10 in large burrows. Surveys in different parts of Hassan and Dakshina Kannada districts showed that one porcupine burrow could be located every sq. km. Twelve burrows, four at each site, were dug and exposed completely. The burrows consisted of a main entrance and several side entrances. The main entrance descended vertically to a depth of 3.5 m in the ground. The large burrows extended to more than 20 m and the small burrows to 8 m. The burrows had three ill-defined chambers; with a big central chamber, and one deep and another raised small chamber on either side. Food was hoarded in the big central chamber. Rearing of young was carried out in one of the small chambers, while the third chamber appeared to be used by the adults. Correlation analysis between the burrow size (sq. cm) and number of porcupines was positive (r=0.89725, P=0.05). However, correlation analysis between the number of porcupines and crop damage at a site showed a weak relationship (r=0.24310), indicating that crop damage was not related to the number of porcupines in a locality.

Table 3: Percent utilization of some economically important and unimportant food plants by the Indian Porcupine in the coastal and hill regions of Karnataka

Food Plants	% damage
Sweet Potato *Ipomea batatas* Lamk.	3% of 20 tubers
Bamboo *Bambusa arundinacea* (Retz.)	8% of 25 tillers
Tapioca *Manihot esculenta* Crantz.	6% of 22 tubers
Alocasia *Alocasia indica* Schott.	2% of 15 tubers
Cashewnut *Anacardium occidentale* L.	10% of 200 nuts
Cane *Calamus tenuis* Redt.	5% of 35 tillers
Sweet Potato *Ipomea batatas* Lamk.	6% of 42 tubers
Ananus *Ananas comosus* (L.) Merr	6% of 350 plants
Banana *Musa paradisiaca* L.	2-8% of 150 plants
Cactus *Agave americana* L.	15-30% of 450 plants
Wild Turmeric *Curcuma aromatica* Salisb.	10-15% of 750 plants
Colacasia *Colacasia indica* L.	10-15% of 50 plants
Gauri Gedde *Gloriosa superba* L.	10-15% of 10 plants
Byne Palm *Caryota urens* L.	15-20% of 15 plants
Acacia *Acacia catechu* Willd.	3-5% of 75 fruits
Coconut *Cocos nucifera* L.	0.03% of 2000 plants

% refers to the number damaged out of the total number, from Jan. 17, 2002 to May 10, 2002

DISCUSSION

Porcupines proved to be a major pest in the coconut plantations in the study area (Table 1). In the Western Ghats region of Karnataka, porcupines injured Coconut, from seedling to mature palms. At the seedling stage, there was no compensatory growth and so the damaged seedlings were lost forever. This was also the case with Areca seedlings. Porcupines have adapted well from scrub jungles and forests to feeding on cultivated plants. Agrawal and Chakraborthy (1992) recorded that the porcupines ate ripe fruits, bark of trees, sugarcane, maize, potato, sweet potato, carrot, onion, ripe melons and other tuberous and bulbous plants, and damaged forest plantations by girdling them. Thus, at each habitat the porcupines foraged on a number of cultivated and wild plant species. As also observed during the current study the porcupines did not depend on a single plant species. By foraging on several plant species, porcupines probably increased their survival rate and fitness. However, the economic loss as a result of porcupines feeding on coconut and arecanut is great, and hence urgent protection measures for the plantation near forests are required.

In the hill region of Karnataka, porcupines were found frequently feeding and damaging areca (*Areca catechu* L.)

seedlings and coconut palms as they are being cultivated in newly cleared forest areas. Porcupines removed small amounts of bark at a time, around 0-75 sq. cm. As the frequency of debarking increased, the amount of damaged bark and the number of palms that were debarked also increased. Porcupines probably supplemented their diet with small quantities of bark which was not used as the main source of food. Debarking depended on a number of factors. In the study area, distance of coconut and arecanut plantations from the forest tract, where the animals usually lived, played an important role. Observations in coastal and hill regions of Karnataka revealed that nearer the plantation from the forest or burrows, higher was the damage inflicted by the porcupines. The porcupines used palm barks more frequently from September to January when the weather was humid and cool. Mortality of palms depended on age – the younger the palm, the greater the damage, and the two parameters were significantly correlated (r=+0.9206). Young palms were probably preferred as they were easy to obtain and digest.

Small burrows were encountered more often than large burrows. The number of individuals corresponded to the size of the burrows (r=+0.89725). However, porcupine density and crop damage at a site were not correlated. The number of animals varied depending on the size of the burrow (2-3 animals in small burrows, 8-10 in large burrows). However, more extensive observations are required to confirm this.

McIntyre (1972) proposed a number of hypotheses to explain bark stripping by ungulates, including the need for high concentrations of trace elements and minerals found in bark, variation in nutritional quality between twigs and barks and low availability of high quality forage. However, the extent of damage to crops by *H. indica* has not been estimated. Further studies using radio-telemetry are in progress. In the Western Ghats, porcupines are frequently hunted for meat by tribals and locals. In addition to this, the natural habitat (forest) and the natural foods of the porcupines are declining rapidly. This may contribute to a decline in porcupine population in the near future. Ecological importance of porcupines in cultivated and natural habitat is yet to be documented. Currently, it is important to sustain natural foods of the animals in wild habitats. A strategy to conserve the species without resulting in severe economic damage to cultivated crops needs to be developed urgently.

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